

Trace Gas Concentrations in Streams: Early Warning Indicators of Stream Impairment?

Author: Roger A. Burke

Key Words: headwater stream impairment, indicators, watersheds, ecosystem function, trace gases

Surface water contamination and resultant impairment of aquatic ecosystem functioning are serious environmental problems, caused in large part by land use changes and excess organic waste inputs associated with agriculture and residential and industrial development. Headwater streams are critical components of river networks, comprising ~95% of the total number of stream channels and ~75% of the total stream channel length in the US, and they frequently exhibit high rates of biogeochemical cycling. Because of their small size, headwater stream ecosystem function is easily impaired by human disturbance of the watershed, riparian zone, or channel. Headwater streams and their watersheds provide valuable ecosystem services such as organic matter processing which provides important resources to downstream ecosystems such as lakes and rivers. As watersheds are increasingly developed to meet human demands, the development of effective and easily measured indicators of watershed impairment will become increasingly crucial. The degrees to which stream concentrations of the biologically reactive trace gases nitrous oxide, carbon dioxide, and methane deviate from atmospheric equilibrium are useful indicators of overall watershed organic matter decomposition rates and metabolism (e.g., anoxic vs. anaerobic, nitrification vs. denitrification). Because stream ecosystem function can be impaired by excess inputs of organic wastes, trace gas concentrations should provide valuable information about stream ecosystem function.

Discussion of the need for effective indicators of organic waste and nutrient loadings to watersheds impacted by human activities with Region 4 and Office of Water (OW) personnel stimulated development of this research activity and it is anticipated that further development of these indicators will be made in collaboration with personnel from OW and various EPA Regions. Results of a one-year study of 17 Georgia Piedmont headwater streams suggest that: (1) total dissolved nitrogen (TDN), dissolved organic carbon (DOC), and dissolved concentrations of nitrous oxide and methane in streams are all effective indicators of stream impairment by nutrients and organic wastes from septic tanks and/or animal manure; and (2) the trace gas concentrations are far more sensitive indicators that respond to much lower levels of nutrient and organic waste contamination than do the bulk parameters TDN and DOC. Elevated levels of nitrous oxide and methane in streams appear to be viable early warning indicators of incipient stream impairment and these indicators, largely being developed through this research, may have great value to water quality managers and regulators in EPA Program Offices and Regions as well as those in state and local governments.

Contact Information: Roger A. Burke
Research Chemist
EPA/ORD/NERL/ERD
(706) 355 8134
burke.roger@epa.gov